Maylor, E. A. (2008). Commentary: Prospective memory through the ages. In M. Kliegel, M. A. McDaniel, & G. O. Einstein (Eds.), *Prospective memory: Cognitive, neuroscience, developmental, and applied perspectives* (pp. 217-233). New York: Erlbaum.

Commentary: Prospective Memory Through the Ages

Elizabeth A. Maylor

University of Warwick, UK

Address for correspondence

Elizabeth A. Maylor
Department of Psychology
University of Warwick
Coventry CV4 7AL
UK
e.a.maylor@warwick.ac.uk

Acknowledgments

Thanks to Richard Darby, Victoria Holman and Joanne Rodger for help with data collection and to Stian Reimers for useful discussion.

Commentary: Prospective Memory Through the Ages

The number of published articles on prospective memory has increased markedly over the past 15 years (see Figure 1 of Marsh, Cook, & Hicks, 2006). A recent *Web of Science* search revealed that almost 40% of 421 articles that included the term "prospective memory" (PM) were concerned with some aspect of age, whether childhood or adult age (the majority on the latter). My task here is to summarise, comment upon, and discuss general themes and unresolved issues arising from, the chapters in this volume on development (Kvavilashvili, Kyle, & Messer), aging (Phillips, Henry, & Martin; McDaniel, Einstein, & Rendell), and the lifespan (Kliegel, Mackinlay, & Jäger). The composition of this section reflects not only the continued interest (and controversy) surrounding PM across adulthood (which was similarly present in the previous volume; Brandimonte, Einstein, & McDaniel, 1996) but also the growing evidence on the early development of PM and the need to take an integrative approach to understand the processes and mechanisms that drive change in PM across the lifespan (cf. Bialystok & Craik, 2006; Graf & Ohta, 2002).

The Development of PM

Kvavilashvili et al.'s (this volume) comprehensive review of the development of PM in children begins by noting the paucity of studies in this area (an unusual case of development lagging aging research). They attribute this to the (mistaken, they argue) assumption that developmental work is unlikely to tell us anything new about PM and also to the undoubted challenges in collecting PM data from young children. (To these explanations, one could perhaps add that it may be easier to justify the study of aging PM to funding bodies because of the obvious importance of everyday PM tasks, such as remembering to take medication and pay bills on time, to living independently in old age.) Nevertheless, there clearly has been some success in designing PM paradigms suitable for children to address these methodological issues, many of which have been encountered previously in the aging literature (see Maylor, 1993b, 1996b; Uttl, 2005, for summaries). For example, it seems to me that the failure of the "feeding the dog" scenario described by Kvavilashvili et al. illustrates the need to avoid the PM requirement becoming a vigilance or monitoring task in the sense that it occupies working memory or conscious awareness throughout the retention interval (see Graf & Uttl, 2001, on the distinction between PM "proper" and vigilance/monitoring).

Also in common with the aging literature, it seems that the data from developmental studies of PM are somewhat inconsistent, which Kvavilashvili et al. (this volume) attribute in part to different policies on whether or not ongoing task difficulty should be adjusted to match the demands on younger and older children. However, the emerging picture appears to be of quite well developed PM in pre-schoolers, with relatively modest improvement with increasing age thereafter. This contrasts with much stronger developmental trends for retrospective memory (RM), but I would argue that such a comparison raises the question of the reliability of PM measures in children. If reliability is low, this limits the amount of systematic variance available to be associated with age. Therefore, a priority for future research should be a study, along the lines of Salthouse, Berish and Siedlecki's (2004) investigation of PM across adulthood, in which children of different ages are administered *multiple* PM and RM tasks (and other measures, such as executive functioning) to first establish their construct validity and only then to compare their developmental sensitivity.

In their concluding remarks, Kvavilashvili et al. (this volume) suggest that further insights might be gained from applying current theoretical models of PM to development, in particular, McDaniel and Einstein's (2000) multiprocess framework. This would predict stronger developmental trends for PM tasks requiring more strategic resource-demanding monitoring but weaker developmental trends for PM tasks relying on more automatic processing (for similar arguments with respect to aging, see McDaniel et al., this volume). Preliminary evidence consistent with this framework as applied to development comes from a study that was briefly described in Maylor, Darby, Logie, Della Sala and Smith (2002). Children aged 6-11 years (*n* = 200) were presented with a series of photographs of their teachers and the children were asked to name each of them (ongoing task). In addition, they were to indicate if the teacher was wearing glasses or if there was a plant in the picture (PM task). Although the glasses were visually much less prominent than the plant, the glasses occurred within the focus of attention for the ongoing task whereas the plant occurred outside the focus of attention (cf. Hicks, Cook, & Marsh, 2005). Responding to the glasses as the PM cue was therefore assumed to be more dependent on automatic processes and less dependent on strategic monitoring processes than responding to the plant.

Almost every child successfully named both the PM target teachers (who were deliberately chosen to be the most familiar to the children). As can be seen in Figure 1, there was general improvement in PM performance with increasing age but this was less striking for the glasses than for the plant, consistent with the predictions from the multiprocess framework. McGann, Defeyter, Reid and Ellis (2005) reported similar trends in a study of 4-7 year olds in which PM target salience was manipulated by increasing the size of the PM stimulus relative to the non-PM stimuli. Clearly, as Kvavilashvili et al. (this volume) point out, this represents a promising approach for future developmental investigations.

Kvavilashvili et al. (this volume) suggest that whereas in laboratory-based studies PM performance generally improves with development, in a naturalistic study of children who were asked to remind their caregivers of various everyday tasks, there was no improvement between the ages of 2 and 4 years and PM success rate was high throughout (Somerville, Wellman, & Cultice, 1983). Thus there is an intriguing hint of a developmental PM paradox (though not a complete cross-over of developmental effects inside vs. outside the laboratory) that deserves replication and further investigation. But it would surely be surprising to find younger children performing *better* than older children on PM tasks outside the laboratory. At least in this respect, development is not the mirror-image of aging, for which there is substantial evidence of an age PM paradox such that young adults outperform older adults on laboratory-based PM tasks, whereas exactly the reverse is the case outside the laboratory (Henry, MacLeod, Phillips, & Crawford, 2004; Rendell & Thomson, 1999). However, a complete explanation for the age PM paradox remains surprisingly elusive.

The Age PM Paradox

Phillips et al. (this volume) provide a critical examination of factors that have commonly been held responsible for the age PM paradox and in particular for the unexpected positive effects of old age on PM performance in naturalistic studies. These data have been too readily dismissed in the past largely because of a lack of experimental control over participants' use of memory aids, ongoing activities, and so on. Note, for example, the comment that "although the study of behavior in context is important, it cannot be a replacement for the systematic study of behavior under laboratory conditions" (p. 184, Maylor 1996b). However, Phillips et al. argue convincingly that it is still important to understand fully the reasons behind the often superior PM performance of older adults outside the laboratory and they helpfully outline the missing crucial studies required to test them.

It seems clear to me that older adults are more highly motivated to succeed in naturalistic PM tasks like phoning the experimenter than are young adults, though why is less clear (but note that the majority of young adults in the naturalistic studies of PM included in Henry et al.'s, 2004, meta-analysis were undergraduate students who may have other priorities). For example, Patton and Meit's (1993) older subjects "indicated that the task was more important to them than it was to younger subjects, confirming the importance of motivation" (p. 175). Rendell and Thomson's (1999) young adults' poor PM performance was attributable to their failure to keep an electronic Organizer with them at all times. Comments from Rendell and Craik's (2000) participants suggested that their older adults took the naturalistic task more seriously than did their young adults. And Kvavilashvili and Fisher's (in press) older adults reported "reliably higher levels of (intrinsic) motivation both before and after completion of the task than younger adults."

Age differences in motivation may also interact with other factors discussed by Phillips et al. (this volume), particularly the use of memory aids. I find it hard to imagine, for example, an undergraduate student turning one item of furniture upside down in every room of the house as a reminder to make a phone call to the experimenter, which was the external cue adopted by one older participant in Maylor's (1990) study. This case (albeit extreme) makes the point that previous categorisations of memory aids as internal, external or conjunction have overlooked the obvious fact that all cues are not equal. As Phillips et al. suggest, we should be wary of the simplistic view that older adults outperform the young in naturalistic PM tasks because they are more likely to adopt external reminders. Instead, I suggest that we focus on the nature of the cues adopted, the effort involved in setting them up, their potential effectiveness, how they interact with the structure of the person's life, how practised the person is in using that particular cue, and so on. An additional question is whether a strategy can be imposed or trained, as illustrated by the following instruction to preachers on a Primitive Methodist Plan of 1857: "….as forgetfulness is not tolerated, he is desired to mark out his appointments and read them over once a week."

Phillips et al.'s (this volume) interesting discussion of ecological validity (see their Table 1) concludes that task setting is most critical in determining whether there are positive or negative age effects on PM, the former being observed "when tasks are set in the day-to-day environment of the participant". It is not clear whether this would include, for example, the population-based study by Huppert, Johnson and Nickson (2000) in which a random sample of people aged 65+ were interviewed in their places of residence by a trained experimenter. Performance on a simple PM task administered during the session declined dramatically and linearly with increasing age. However, although the task setting was the everyday environment of the participant, the PM task was still under the control of the experimenter (and the same would apply to the web-based study to be described later, despite the physical absence of an experimenter in that case) – see Phillips et al.'s section on Participant Control.

The hypothetical scenario posed by Phillips et al. (this volume) is especially sobering in that it highlights just how little we have learned from decades of both naturalistic and laboratory work on aging and PM about older people's actual performance in everyday PM tasks. These would include not only those habitual PM tasks usually listed in the introductory sections of articles and grant proposals (remembering to take medication, pay the bills, etc) but also "tasks that crop up unexpectedly during the day" (P268, Rendell & Thomson, 1999) such as remembering to set the video to tape a television programme, turn off the bath taps or the electric blanket, prompt a friend who has asked you to remind them of something when they leave, phone someone back in an hour when they will be available, and so on. As Phillips et al. note, we simply do not know whether aging data from naturalistic- or laboratory-based tasks are more appropriate to everyday PM situations. This seems a disappointing state of affairs but one that could be remedied by following the recommendations for future research outlined in their chapter, including systematic manipulations of relevant factors across both naturalistic and laboratory settings, and also direct observational studies. It would for instance be interesting to discover the extent of collaboration and reliance on others in prospective remembering across adulthood (see Schaefer & Laing, 2000).

Aging PM in the Laboratory

The age PM paradox is of course a generalization that ignores the fact highlighted by McDaniel et al. (this volume) that age-related deficits are not always observed in laboratory-based PM tasks. Thus it is now recognised that PM tasks vary in their attentional demands, with age differences greater under more demanding conditions consistent with McDaniel and Einstein's (2000) multiprocess framework (see Henry et al., 2004; Maylor et al., 2002). In their chapter, McDaniel et al. explore in detail a distinction between focal and nonfocal cues in event-based PM tasks, the former eliciting more automatic spontaneous retrieval than the latter because of their "overlap with the information constellation relevant to performing the ongoing task". This is reminiscent of an earlier notion of "task appropriate processing" (p. 78, Maylor, 1996a), which suggested that a key to understanding age differences in PM was in terms of the relationship between the type or level of stimulus processing required to perform the ongoing task and stimulus processing required to perform the PM task (see also Maylor et al., 2002). Although McDaniel et al. argue that these two ideas are not the same, it seems to me that they are conceptually very similar and indeed make identical predictions. Taking their example of making lexical decisions as the ongoing task and indicating a member of the animal category as the PM task, McDaniel et al. define this as task appropriate (because both are semantic tasks) but nonfocal (because deciding if a letter string is a word "does not require processing the semantic features necessary to make a category determination"). Instead, I would define this as task inappropriate because the processing required to decide if a letter string is a word is insufficient for a participant to realise that it is a member of a particular category. Maylor (1996a) similarly defined Mäntylä's (1993) condition in which the ongoing task was word association and the PM cue was any member of a particular category (e.g., liquids) as task inappropriate because a shift was required in the level of processing from the generation of a semantically related word to the categorization of that word as a member of a specific group. A task appropriate version of McDaniel et al.'s example would be lexical decision as the ongoing task and indicating the word "cat" as the PM task. Thus, I would claim that all the nonfocal cases in McDaniel et al.'s Table 1 are task inappropriate and all the focal cases are task appropriate. In other words, in all the nonfocal cases, some additional (self-initiated) processing, beyond that required by the ongoing task, is necessary for the PM cue to be detected as such.

Terminology aside, the data are reasonably consistent in showing smaller age-related deficits with focal than with nonfocal cues (e.g., Maylor et al., 2002; McDaniel et al., this volume; Rendell, McDaniel, Forbes, & Einstein, in press; Salthouse et al., 2004). However, the data are less consistent on the question of whether age deficits can be eliminated altogether with focal cues. For example, Salthouse et al. observed age deficits in their PM tasks with focal cues (namely, "drawing classification" and "concept identification") and several of my own attempts to replicate Einstein and McDaniel's (1990) classic findings of no age deficits with focal cues have failed (Maylor, unpublished data). Some reasons for these discrepancies will be discussed later.

One important possibility identified by McDaniel et al. (this volume) that has been ignored in past studies is that perhaps older adults may be able to achieve an equivalent level of PM performance to that of the young but only by sacrificing ongoing task performance. Investigating this obviously requires monitoring ongoing task performance both with and without the PM task to obtain a measure of PM costs (and this should probably be routine in future PM studies). McDaniel et al. present data with focal cues suggesting that the absence of age-related deficits in PM is not accompanied by greater costs to the ongoing task in older adults. These results are striking but they do raise a couple of concerns. The first is the extent to which performance is at or close to ceiling – note that although focal PM performance was not actually 100%, PM may be subject to a "functional measurement ceiling" (p. 1143, Salthouse et al., 2004) that is effectively lower than 100%. (This ceiling issue also complicates the interpretation of Age x Condition interactions, where condition might be focal/nonfocal, salient/nonsalient, event-based/time-based, etc.)

The second point is that in addition to considering ongoing task performance more closely as advocated by McDaniel et al. (this volume), we should examine PM performance in greater detail. Traditionally, only accuracy is considered. But evidence that more might be learned from other measures, reaction time (RT) in particular, comes from an unpublished study I conducted in collaboration with Maria

Brandimonte. The PM task was embedded within an ongoing letter-matching task. Participants were presented with strings of five letters and were asked to decide whether the second and fourth letters in each string were the same or different (letter-matching task). They were additionally instructed that if one or both of these letters was the letter "B," then they should press the spacebar before making the usual same/different response (PM task). PM targets occurred twice in each of 8 blocks of 65 trials. There were 26 young and 34 older participants with mean ages of 21 and 70 years, respectively, although the data from four participants (1 young; 3 older) were excluded from the analysis because they did not perfectly recall every element of the instructions when questioned at the end of the experiment. On the letter matching task, both age groups were highly accurate (around 97% correct) but young adults were faster than older adults (*M* RTs of 839 and 1267 ms, respectively, an age-related slowing factor of 1.5). For the PM task, young adults were numerically but not significantly more successful than older adults (63 and 57% correct, respectively), consistent with a classification of the PM cue as focal. However, the PM responses of young adults were considerably faster than those of older adults (*M* RTs of 1225 and 2337 ms, respectively, an age-related slowing factor of 1.9). This particularly marked slowing of older adults' PM responses (also observed by West & Craik, 1999, though using a nonfocal PM cue) could reflect greater difficulty in inhibiting the ongoing task response, slower retrieval of the PM action required, and so forth. Whatever the explanation, the point here is that PM performance in focal tasks may not be entirely indistinguishable between young and older adults and that we may be missing more subtle and potentially interesting age-related deficits in PM by generally focusing on percent correct as the dependent variable.

McDaniel et al.'s (this volume) most intriguing result is the absence of reliable age-related deficits in PM for nonfocal cues (requiring strategic monitoring), which was associated with disproportionate costs to ongoing task performance in older adults. In other words, for whatever reason, their older adults apparently chose to prioritize PM performance at the expense of ongoing task performance. Why older adults in previous studies of nonfocal PM tasks (e.g., Maylor, 1998) apparently chose not to do this is a puzzle (but see discussion later on task instructions) that should be addressed in future research.

It is suggested by McDaniel et al. (this volume) that their laboratory-based findings can help to reconcile the age PM paradox. Thus, they argue that age deficits will not occur in naturalistic PM tasks when the cue is focal because performance relies on spontaneous retrieval processes that are preserved in old age. Nor will they necessarily occur in naturalistic PM tasks when the cue is nonfocal because ongoing task performance can be sacrificed or adjusted to take the PM task into account. However, aside from the difficulties in extrapolating from the laboratory to naturalistic settings (see Phillips et al., this volume), such arguments fail to explain the *positive* effects of aging observed in naturalistic PM tasks. Nonetheless, McDaniel et al.'s provocative discussion opens up some interesting new lines of enquiry.

McDaniel et al. (this volume) close by mentioning other factors besides the focal-nonfocal distinction that may influence the extent of age effects in laboratory-based PM tasks, one of which is time of day. Significant effects of time of day were reported by Leirer, Decker Tanke and Morrow (1994) in a naturalistic study of older adults who were required to simulate taking medication at specified times each day. PM performance was best in the morning, a result they attributed to the morning hours being less busy (see Rendell & Thomson, 1999, for a similar result). If time of day effects were found in laboratory-based PM tasks, they would presumably require a different explanation because ongoing activity would be controlled.

Time of day has received some recent attention in the aging literature (see Yoon, May, & Hasher, 2000, for a review) because whereas most young adults describe themselves as "neutral" or "evening" types, most older adults are "morning" types. Moreover, cognitive performance for young adults tends to be better when tested in the afternoon than in the morning, with precisely the reverse for older adults. For example, May, Hasher and Stoltzfus (1993) observed substantial age deficits in recognition memory in the late afternoon (optimal for young but not older adults) but no age deficits in the morning (optimal for older but not young adults). Therefore, a potential explanation for the conflicting effects of aging on laboratory-based PM tasks in the literature is that studies have been conducted at different times of the day, with those showing no age deficits conducted in the morning and those showing age deficits conducted in the afternoon. Unfortunately, such information is not usually reported in laboratory-based PM studies.

Preliminary evidence from young adults in the laboratory comes from an unpublished study in which 94 undergraduate students were tested either in the morning or in the afternoon. The ongoing task was either to name famous people from their photographs or to provide their occupations (half assigned to each condition) and the PM task was to indicate those wearing glasses (cf. Maylor, 1996a, 1998). Figure 2 shows correct performance on the ongoing and PM tasks (name and occupation data were combined) as a function of time of day. There was no overall effect of time of day but there was a significant interaction with task ($p < .05$) indicating that PM performance was relatively better in the morning and ongoing performance was relatively better in the afternoon. The reason for this is unclear – one possibility is that there are differential and independent effects of time of day on retrieval from semantic memory (ongoing task) and PM; another possibility is that participants adopt different strategies or tradeoffs in the allocation of attentional resources between the ongoing and PM tasks in the morning and afternoon. Whatever the explanation, these data suggest that time of day should be considered in future studies (though time of day effects may be more apparent with nonfocal than with focal PM cues), particularly those involving different age groups.

Lifespan Changes in Complex PM

In contrast to the rather weak developmental improvements in PM reviewed by Kvavilashvili et al. (this volume) and the absence of age deficits in PM obtained by McDaniel et al. (this volume), Kliegel et al. (this volume) report a wealth of data showing marked inverted-U-shaped changes in performance across the lifespan. Importantly, their task is a complex planning task with presumably high demands on executive functioning, in which the PM component as I have previously understood it – for example, “the requirement to remember to perform an action at some point in the future…in the absence of any prompting by the experimenter” (p. 175, Maylor, 1996b) – is only one element (i.e., intention initiation) of the intention formation-retention-initiation-execution process. Kliegel et al.’s paradigm was designed to explore lifespan changes in each of these phases in a complex PM task. Impressive data and combined plots from 555 participants over a wide age range (6-84 years) show that growth, stability then decline (in some cases accelerating) are evident in all phases but particularly for initiation and execution. Furthermore, an increase in the need for inhibitory control in the execution phase exaggerated age effects across the lifespan.

At least as implemented in Sections 2 and 3 of Kliegel et al. (this volume), the task's emphasis is on how participants form a plan to follow a set of arbitrary rules, retain the plan, and then later carry it out without breaking the rules (see their Footnotes 1, 2 and 4). However, I would argue that the paradigm fails to capture what is perhaps most relevant to PM and that is the formation, retention and execution of a plan for initiating an intention. Thus, in view of the PM instructions to self-initiate the multitask set on encountering the PM cue (i.e., a request to write date of birth at the top of a questionnaire – see Footnote 3), of most interest is what participants of different ages do to ensure that they will remember, whether their methods are effective, and so forth. In fact, Section 4 begins to address this potential criticism by introducing conditions that include specifically instructing participants to consider planning aids that would target the intention initiation component. Nonetheless, it remains of interest to discover the extent to which participants of different ages focus on intention initiation or execution in their spontaneous plans and how these then relate to success or otherwise in each phase.

Another possible reservation concerning Kliegel et al.'s (this volume) paradigm is that it may not be relevant to performance outside the laboratory (though this criticism also applies to other laboratory PM tasks, of course). For example, Kliegel et al. consistently observed that older adults formed less elaborate plans in comparison with young adults. However, while others have also found age deficits in formulating and executing plans with novel tasks, it seems that if the planning task is more familiar/ecologically valid, age differences disappear (see Phillips et al., this volume). This is not to deny the potential value of Kliegel et al.'s paradigm for addressing questions such as the role of various explanatory mechanisms in each of the phases, but it does suggest some caution in interpreting the data and drawing conclusions from the paradigm.

General Themes, Unresolved Issues, and an Internet Study

One common theme running through these chapters is the age-complexity effect, which refers to the tendency for age (and developmental) differences in performance to increase with the complexity of the task (see Salthouse, 1991, for discussion). Age-complexity is related to the reduced processing resources view whereby older adults and young children have fewer processing resources or less attentional capacity than young adults; they are therefore particularly disadvantaged in complex tasks that are more demanding and less automatic (Hasher & Zacks, 1979). Although this view enables us to make relative predictions such as lifespan changes should be more dramatic for nonfocal than for focal PM cues, it is less helpful in making absolute predictions about whether any particular PM task will show age differences. The argument becomes circular if we find a reliable age difference in PM performance and therefore conclude that retrieval was not automatic. A possible added complication is that sometimes PM tasks that appear more complex result in superior performance. For example, Maylor (1993a) asked participants to name famous faces and to circle the trial number if the person had a beard and cross out the trial number if the person was smoking a pipe. Maylor (1996a) asked participants to name famous faces and to circle the trial number if the person was wearing glasses. PM performance in the first block of trials was much higher with the former more complex instructions than with the simpler instructions (68% vs. 42% correct). It seemed that greater effort was made to encode the complex instructions, which may also have been mentally rehearsed more often subsequently because of their perceived difficulty. A related argument was made by Henry et al. (2004) in categorising 6-

event and 12-event PM conditions as requiring high and low strategic demands, respectively, on the grounds that the greater frequency of PM cues would "presumably maintain activation of the PM task" (p. 29). In short, the age-complexity notion may not necessarily prove to be so helpful in the context of PM.

Another emerging theme is the somewhat inconsistent nature of the PM findings in both the developmental and aging literatures. Of course, some contrasting data patterns have led to interesting proposals like the age PM paradox that should continue to inspire researchers. But other inconsistencies raise the general issue of the reliability/validity of PM measures across the lifespan. In the only large-scale study of several different laboratory event-based PM tasks, Salthouse et al. (2004) found that although their PM tasks showed both convergent and discriminant validity, little of the variance in each task was associated with what they had in common (unlike, e.g., RM). They therefore concluded with a note of caution to researchers trying to make inferences about the construct of PM based on results from a single task. No such equivalent data exist for naturalistic PM tasks, which represents a gap that urgently needs to be filled.

Inconsistent results also highlight both the logical and methodological problems associated with the investigation of PM. Thus, single binary measures of success/failure on laboratory tasks such as remembering to ask for a red pen at the appropriate moment (designed to simulate everyday "crop-up" tasks mentioned earlier) are noisy, coarse indices of PM ability. Increasing the number of PM trials introduces other complications – for example, it risks the task becoming one of vigilance (Uttl, 2005); also, performance on the first PM trial may be influenced differently by factors such as aging to performance on subsequent PM trials (Maylor, 1996b).

A novel way of producing a more finely-grained index of PM performance from a single PM response was recently described by Graf, Uttl and Dixon (2002). Participants are shown the PM cue (e.g., a picture of a helicopter) and instructed to stop performing the ongoing task (e.g., categorising letters presented in the center of the computer screen) when the PM cue occurs in one of the corners of the screen. Each ongoing task trial is accompanied by four pictures of different sizes. The PM cue when it first appears is small and if the participant fails to respond, it reappears a few trials later but slightly larger. This procedure continues until the participant responds, the dependent variable being the size of the cue at that point. Using this simple method, Uttl (2006) observed significant age-related deficits in PM with both visual and auditory cues, older adults requiring larger and louder PM cues, respectively, before responding. It would seem quite straightforward and potentially interesting to extend this paradigm to the study of PM development.

An alternative solution to the problem of noisy, coarse data from single-event PM tasks is to compensate by increasing the numbers of participants in the study. This could be achieved by collecting data via the Internet. With the enormous recent growth in access to the Internet has come a rapidly expanding literature reporting psychological experiments conducted online (see Birnbaum, 2004; Reips, 2002, for reviews). There are many obvious advantages of such methodology. For example, it can save researchers both time and money as once an experiment is set up, it can be run concurrently on large numbers of unpaid volunteers. These generally represent a wider demographic than the usual undergraduate population and hence the results may be more generalisable. Experimenter bias can be avoided because Internet experiments run automatically. To these can be added a couple of particular advantages with respect to research on aging, namely, participants are not required to travel for testing, and older adults are probably less anxious when tested in their own familiar environment.

Of course, there are also some obvious disadvantages associated with Internet experimentation. These include the possibility of a biased sample as although most people now have access to computers, not everyone will have the appropriate software installed for downloading and running experiments. People may not be honest, for example, in answering questions about demographics (age, education, gender, etc). More importantly, they may not always understand the instructions and, unlike laboratory research, there is no opportunity to check and provide further instructions if necessary. Internet studies provide no control over the conditions under which the experiment is conducted – uncontrolled factors include monitor size, hand positions, distractions, noise, time of day, and so on. Also, there is no control over the state of participants who, for example, may be tired, intoxicated, or not wearing their glasses.

However, in view of the large numbers of people who can be tested in Internet studies, researchers can ensure the integrity of their data by taking a conservative approach to the datasets they allow to enter the analysis. In general, this methodology tends to produce effects that account for only a small proportion of the variance but are highly significant. The effects may be more generalisable to real world situations if they emerge from experiments conducted on diverse samples under poorly controlled conditions. It is therefore argued that the considerable advantages more than outweigh the disadvantages, particularly as evidence suggests that web-based studies can reliably replicate laboratory findings (see Buchanan & Smith, 1999; Gosling, Vazire, Srivastava, & John, 2004; McGraw, Tew, & Williams, 2000).

Access to the Internet is now widespread in schools; older adults are also increasingly being encouraged to use the Internet although home access decreases with age (Cutler, Hendricks, & Guyer, 2003; Selwyn, Gorard, Furlong, & Madden, 2003). Thus there is currently enormous potential for conducting lifespan research online. Recent published examples include a study on self-esteem by Robins, Trzesniewski, Gosling and Potter (2002) with 326,641 individuals aged between 9 and 90 years, and a study of task switching by Reimers and Maylor (2005) with 5,271 participants between 10 and 66 years.

In collaboration with Robert Logie and the British Broadcasting Corporation (BBC), Internet data are currently being collected on a set of memory experiments that includes a simple PM task. Toward the beginning of the session, participants view a screen informing them that later in the test, they will see a smiley face and they have to remember to click on the smiley face when it appears. This PM cue is presented in the top right-hand corner of the screen that provides feedback to the participant after the tests have been completed. There is no time limit imposed on viewing either the instruction screen or the feedback screen. Preliminary results from 1,199 UK volunteers aged between 16 and 77 years from the first five days of data collection are presented in Figure 3.[1] The point-biserial correlation between exact age and PM success was weak but highly significant, $r_{pb} = -.201$, $p < .001$. Thus, although the task setting was the participants' own familiar environment, there was approximately linear age-related decline in PM performance from young adulthood. Internet methodology may therefore be a promising avenue to pursue in the future, particularly with respect to the investigation of PM in neglected age groups such as adolescents and 20-40 year olds.

Returning to the issue of discrepancies in the literature, a significant source of variance across PM studies may lie in the exact wording of the task instructions, which are not always reported but perhaps should be routinely included in Appendices. As noted by Phillips et al. (this volume), age deficits can vary in the laboratory depending on the relative emphasis in the instructions on the ongoing vs. PM tasks. Performance may also be influenced by whether the PM task is described explicitly as a test of memory as shown by Gao, Cuttler and Graf (2005) who administered a neuropsychological test battery to 141 community-living adults. Prior to starting the tests, the experimenter unplugged the phone to prevent disruptions and asked the participant to remind the experimenter to plug the phone back when testing was completed. Half of the participants were assigned to an “informed” condition in which they were told that the phone task was designed to assess their memory, whereas the other half were in a “naïve” condition in which they were not told that the phone task was a memory test. Informed participants were significantly more successful in remembering to remind the experimenter than were naïve participants (approximately 59% and 28%, respectively).

The importance of the precise wording of instructions with respect to aging is highlighted by intriguing data from a study of RM by Rahhal, Hasher and Colcombe (2001; see also Desrichard & Köpetz, 2005). When the instructions emphasised the memory component of the task (e.g., “You will be tested on your memory of this information in phase two”), age deficits were observed. However, when the instructions were phrased more neutrally (e.g., “You will be tested on this information in phase two”), there were no age differences. Although task instructions are unlikely to account entirely for discrepancies in the PM literature,[2] they surely deserve serious consideration in the design of future aging (and perhaps developmental) studies.

From a lifespan perspective, several important issues remain largely unresolved. First, as mentioned in more than one chapter, all our present conclusions are based on cross-sectional data so there is obviously a need to replicate PM findings longitudinally. Second, there are at least some hints that PM may be more strongly related to RM and other aspects of cognition in childhood and old age than in adulthood, consistent with the differentiation-dedifferentiation view of intellectual development across the lifespan (see Li, Lindenberger, Hommel, Aschersleben, Prinz, & Baltes, 2004) but clearly further data are required. Third, although there appear to be some parallels between the two ends of the lifespan in terms of mechanisms and processes underlying the development and aging of PM (changes in executive functioning, inhibitory control, speed of processing, etc), there may also be some differences (cf. Craik & Bialystok, 2006). For example, it seems unlikely that the significant contribution to PM performance from sensory functioning found in old age (Uttl, 2006) will be replicated in development.

In summary, over recent years there has been considerable progress in research on PM in both development and aging. Studies are now more theory-driven and beginning to benefit from improved methods and insights from wider domains. However, a nagging question relevant to all these chapters is whether any of the findings would particularly surprise a developmental/aging RM researcher. The age PM paradox perhaps stands out as the most unexpected; it would perhaps further surprise an RM researcher to learn that there is still no completely satisfactory explanation for it.

Footnotes

[1]Participants were in fact randomly assigned by the computer program to one of four conditions in this PM experiment; for present purposes, the data have been combined across the different conditions to produce Figure 3.

[2]For example, compare the PM instructions in a study with no age deficits in which participants were told that the experimenters "had a secondary interest in their ability to remember to do something in the future" (p. 719, Einstein & McDaniel, 1990), and a study with age deficits in which the experimenter told participants "If you see a person wearing glasses, then I want you to put a circle around the number of that slide" (p. 75, Maylor, 1996a).

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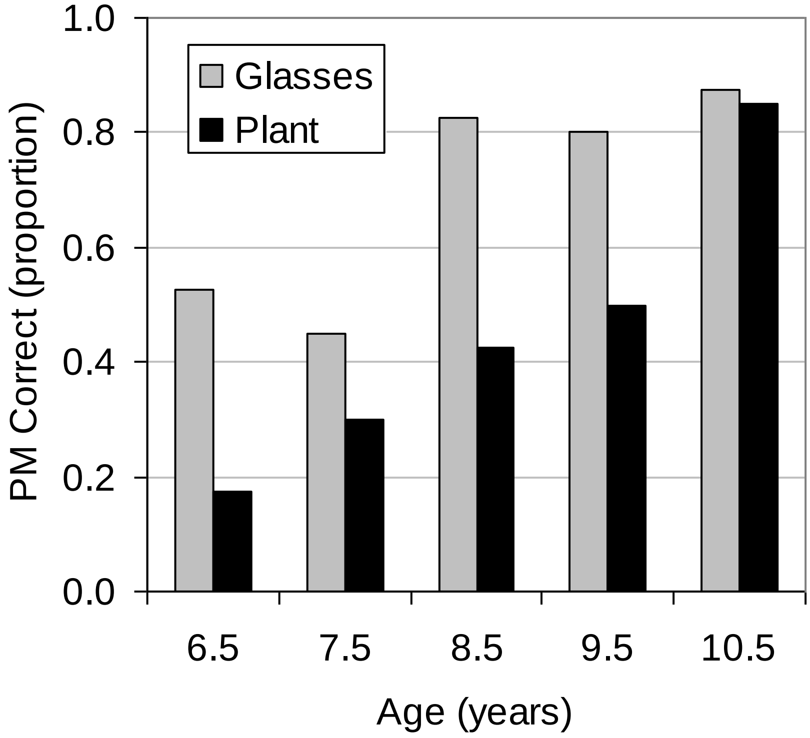
Figure Captions

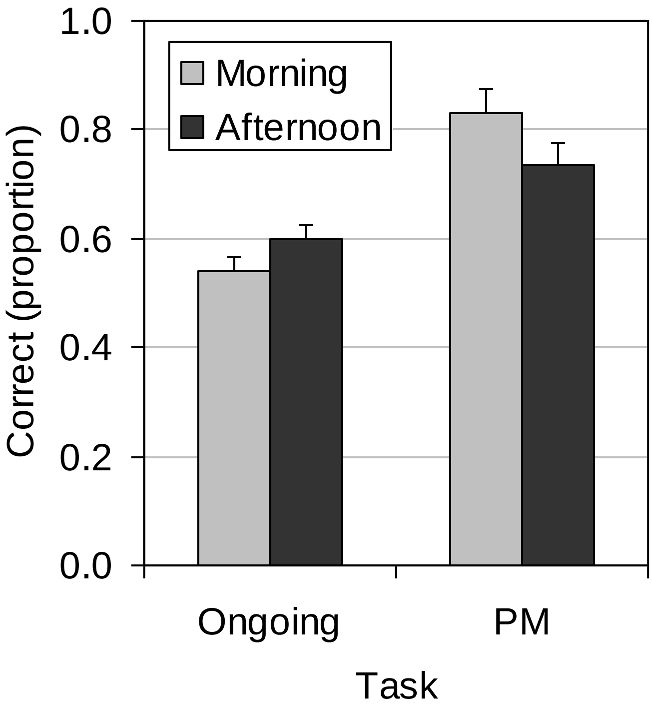
Figure 1. Proportion of children in each of five age groups (mean ages 6.5-10.5 years; *n* = 40 per group) who responded successfully to each of two PM targets (a teacher wearing glasses; a plant in the picture) while naming their teachers from photographs (ongoing task). From Maylor (unpublished data).

Figure 2. Mean correct performance from 94 undergraduate students, half of whom were tested in the morning and half in the afternoon, for the ongoing task (providing the names or occupations of famous people from their photographs) and the PM task (circling the trial number of those people wearing glasses; *n* = 8 out of 120). Error bars indicate 1 standard error of the mean. From Maylor (unpublished data).

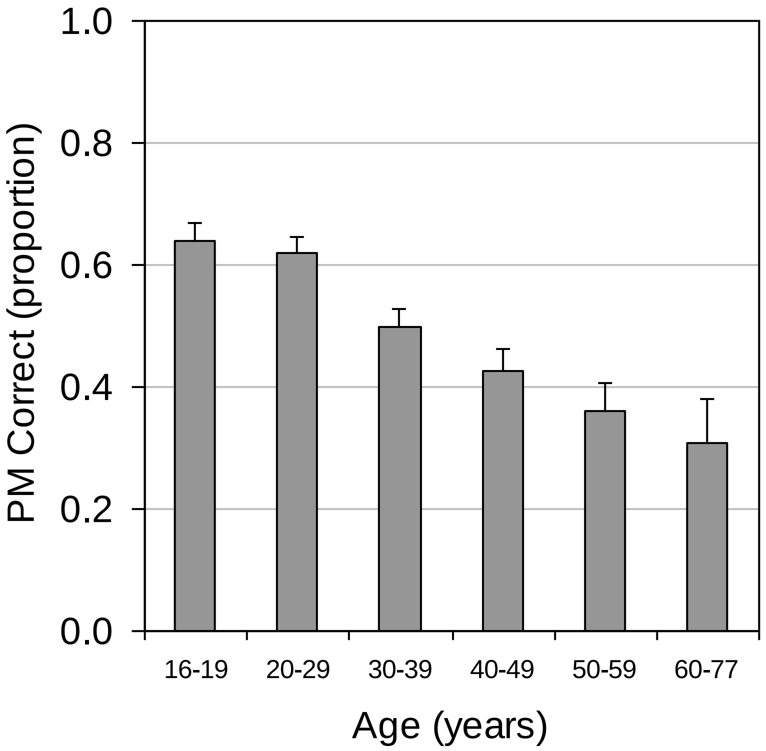
Figure 3. Mean proportion of participants in each of seven age groups from 16-77 years (*n* = 232, 343, 283, 188, 111, and 42, respectively) who responded correctly to a single PM target event in an Internet study of memory run from the BBC's Science and Nature website. Error bars indicate 1 standard error of the mean. Preliminary results from UK participants in the first five days of data collection (Logie & Maylor, unpublished data).



1.0
0.8
0.6
0.4
0.2
0.0
PM Correct (proportion)
Glasses
Plant
6.5
7.5
8.5
9.5
10.5
Age (years)



1.0
0.8
0.6
0.4
0.2
0.0
Correct (proportion)
Morning
Afternoon
Ongoing
PM
Task


1.0
0.8
0.6
0.4
0.2
0.0
PM Correct (proportion)
16-19
20-29
30-39
40-49
50-59
60-77
Age (years)